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Evidence for the non-influence of salinity variability on the *Porites* coral Sr / Ca palaeothermometer

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Abstract. *Porites* coral-based sea surface temperature (SST) reconstructions are obtained from the measurement of skeleton Sr / Ca ratio. However, the influence of salinity in the incorporation of these trace elements in the *Porites* aragonitic skeleton is still poorly documented. Laboratory experiments indicate that in three different coral species (not including the widely used *Porites* genus), salinity does not influence the Sr / Ca thermometer. In this study, we test the salinity effect on *Porites* Sr / Ca-based SST reconstructions at monthly and interannual timescales in open-ocean environmental conditions. We use a large spatial compilation of published *Porites* data from the Red Sea and Pacific and Indian oceans. Additionally to those published records, we add a new eastern Pacific coral Sr / Ca record from Clipperton Atoll.

Using two different salinity products (Simple Ocean Data Assimilation (SODA) SSS reanalyses version 2.2.4, Carton and Giese, 2008; and instrumental SSS from the Institut de Recherche pour le Développement, France (IRD) Delcroix et al., 2011), we find no evidence of salinity bias on the Sr / Ca SST proxy at monthly and interannual timescales. We conclude that *Porites* Sr / Ca is a reliable palaeothermometer that is not influenced by salinity variability.

1 Introduction

Massive scleractinian corals have been extensively used in the past 3 decades as a source of environmental information for the tropical belt at different timescales (from weekly to multi-annual) (Cole et al., 1993; Gagan et al., 1998; Cobb et al., 2003; Corrège, 2006; Linsley et al., 2006; Jones, 2009; Delong et al., 2012 and therein). The hermatypic *Porites* genus is one of the most suitable coral for reconstructing past oceanic parameters such as sea surface temperature (SST) and for estimating qualitatively the sea surface salinity variability (SSS). Massive *Porites* corals have a wide distribution area in the Pacific, a strong resistance to breakage and erosion and often seasonal banding allowing the establishment of a reliable chronology (Knutson et al., 1972; Barnes and Lough, 1993; Corrège, 2006).

Among the different geochemical tracers used in coral-based palaeoclimatology, the Sr / Ca ratio has been shown to be the most robust and straightforward coral geochemical proxy for reconstructing past SST changes (Smith et al., 1979; Beck et al., 1992; Alibert et McCulloch, 1997; Corrège, 2006; Nurhati et al., 2009; Delong et al., 2012; 2013). Sr^{2+} ions substitute for Ca^{2+} ions in aragonite depending on temperature and are therefore strongly bound to the crystal lattice (Amiel et al., 1973; Mitsuguchi et al., 2001; Watanabe et al., 2001; Allison et al., 2001; Finch et al., 2003).

Site-specific calibrations are usually necessary to obtain the best-possible Sr / Ca–SST calibration (see Corrège 2006 for a compilation of published calibrations). In spite of this, several sources of noise and error can interfere when generat-

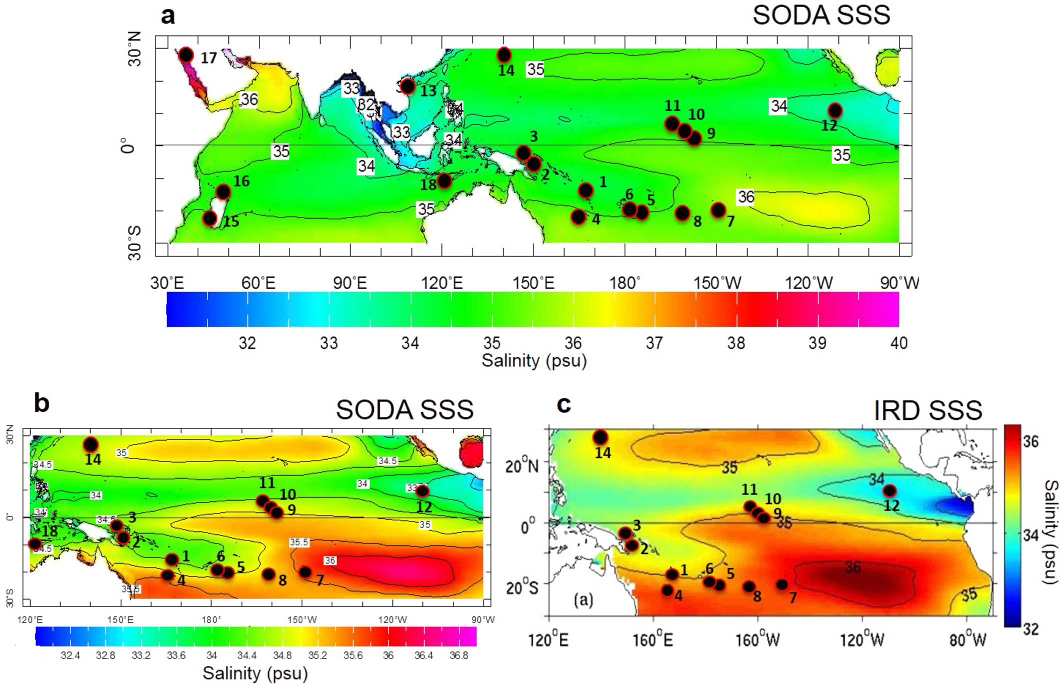

Figure 1. Study sites (black and red circles) plotted over averaged salinity maps. **(a)** SODA SSS product v2.2.4, Carton and Giese (2008) averaged over 1982–2008; **(b)** same as **(a)** but zoomed over the tropical Pacific Ocean to highlight the salinity structure in that zone and to compare it with instrumental IRD SSS product; **(c)** instrumental IRD SSS product (figure from Delcroix et al., 2011) over the 1950–2008 period.

ing SST time series from Sr / Ca calibration. Intrinsic effects such as "vital effects" could be due, for example, to zooxanthellae photosynthetic activity (Thompson and Livingston, 1970; Cohen et al., 2002) and growth rate variations (de Villier et al., 1995; Alibert and McCulloch, 1997; Mitsuguchi et al., 2003, Goodkin et al., 2007). Recently, a study showed that skeletogenesis within the living tissue layer could lead to an overestimation of reconstructed SST (Gagan et al., 2012). Additionally, environmental factors such as spatial and temporal variations of the seawater Sr / Ca ratio could influence coral Sr / Ca records (de Villier et al., 1995; Shen et al., 1996; Sun et al., 2005). Problematic skeletal architecture when sampling *Porites* slab can also produce bias in SST reconstruction of up to $\sim \pm 2\,^{\circ}$C (Delong et al., 2013). On the other hand, instrumental temperature measurements contain observational bias corrections (Rayner et al., 2003) or uncertainties due to SST data interpolation in some database such as HadISST (Rayner et al., 2003) and ERSST (Smith et al., 2008) (Smith et al., 2006; Maupin et al., 2008; Pfeiffer et al., 2009; Hetzinger et al., 2010; Scott et al., 2010; Deser et al., 2010; Flannery and Poore, 2013; DeLong et al., 2014).

Coral δ^{18}O reflects SST as well as changes in seawater δ^{18}O. Coupled measurements of Sr / Ca and δ^{18}O in coral samples have been used to estimate past variations in the seawater oxygen isotopic composition (δ^{18}Osw) (McCulloch et al., 1994; Gagan et al., 1998; Ren et al., 2003). δ^{18}Osw and SSS are affected by the same processes in the tropics (the precipitation to evaporation ratio, vertical and horizontal advections) therefore, the combination of Sr / Ca and δ^{18}O measurements in corals can theoretically provide information on SST and qualitative SSS changes through time (Gagan et al., 1998; Ren et al., 2003; Cahyarini et al., 2008). However, it is necessary to ensure that salinity does not influence the Sr / Ca thermometer in the first place. The pioneering work of Weber (1973) demonstrated the potential role of water depth, seawater composition and salinity on physiological processes that in turn control skeletal chemistry. Since this study, the possibility of a salinity influence on coral Sr / Ca has been discussed without reaching a definitive consensus (Swart, 1981; Sinclair et al., 1998; Shen et al., 2005). Furthermore, other studies have investigated the effect of fluvial discharges (i.e. locally decreasing the SSS) and found no measurable influence on the Sr / Ca–SST calibration despite the fact that riverine inputs can potentially alter the Sr / Ca ratio of seawater (Alibert et al., 2003; Fallon et al., 2003 Stephans et al., 2004). Nevertheless, these studies were rather local and did not encompass a large salinity range. A recent laboratory experiment based on three different coral genera (*Acropora* sp., *Montipora verrucosa* and *Stylophora pistillata*) found no effect of salinity (in the range 36–40 psu) on Sr / Ca, but this study did not encompass the *Porites* genus (Pretet et al., 2013).

Until recently, testing potential salinity bias on coral Sr / Ca thermometry was difficult because most coral Sr / Ca records originated in the western tropical Pacific Ocean, a region characterised by a weak spatial mean salinity gradient (34.4–35.6 psu) (see Fig. 1 and Delcroix et al., 1998; Delcroix et al., 2011). Several *Porites* Sr / Ca records are now available in other regions encompassing a much larger salinity range (∼ 7 psu) such as the western subtropical North Pacific Ocean, the western tropical South Indian Ocean, the South China Sea, the Indonesian Throughflow region and the Red Sea. In this paper we extend the spatial coverage of available Sr / Ca data by presenting a newly obtained eastern tropical North Pacific coral record from Clipperton Atoll. The compilation of these coral records permits a better geographical and spatial investigation of the salinity influence on the coral Sr / Ca palaeothermometer in multiple open-ocean conditions at seasonal and interannual timescales.

2 Material and methods

2.1 Clipperton record (10°18′ N, 109°13′ W)

In February 2005, a sampling expedition led by the Institut de Recherche pour le Développement, France (IRD), collected a 1.94 m long *Porites* core (labelled CL3) at 10 m water depth with a hydraulic drill. CL3 was cut in several slabs of 1 cm of thickness with a circular saw, along the main growth axis to allow the continuous sampling of corallites. The first two slabs (44 cm length in total) were cleaned with deionized water in an ultrasonic bath for 10 min and then air dried at room temperature for 24 hours. Micro-sampling of the two slabs was conducted with a computer-controlled three axis positioning system and a micro-drill at 1.5 mm increments to obtain a near-monthly resolution (based on a mean annual growth rate estimated from X-radiographs, not shown).

The Sr / Ca record from CL3 was generated on a VARIAN Ultramass® ICP MS (inductively coupled plasma mass spectrometer) at the IRD centre in Bondy (France), following the method developed by Le Cornec and Corrège (1997) (Fig. S1 in the Supplement). Powdered carbonate samples (∼ 1 mg; 277 samples) were dissolved in 8 mL of 2% nitric acid with a target concentration of ∼ 40 ppm for Ca and ∼ 0.8 ppm for Sr. An in-house coral standard was repeatedly measured ($n = 92$) achieving a standard deviation of ±0.05 mmol mol^{-1}. We obtained a 22-year coral record spanning from 1982 to 2004. The chronology is based on maxima and minima peak matching between Sr / Ca and the OISST (NOAA optimum interpolation (OI) sea surface temperature) monthly product (version 2, Reynolds et al., 2002). The monthly Sr / Ca data were linearly interpolated (12 times per year) using the AnalySeries software (Paillard et al., 1996).

2.2 Coral database

We compiled all the publicly available seasonally and annually resolved *Porites* Sr / Ca records from the NOAA and Pangaea palaeoclimatology databases (http://www.ncdc.noaa.gov/data-access/paleoclimatology-data and http://www.pangaea.de/, respectively). These seasonal to annual resolution records cover various intervals of 5 to 25 years within the last 3 decades (Table 1 and Fig. 1). Our database is composed of 18 records: one in the eastern tropical North Pacific Ocean (this paper), three in the central equatorial Pacific Ocean (Palmyra, Fanning and Christmas; Nurhati et al., 2010), six in the western tropical South Pacific Ocean (Rarotonga; Linsley et al., 2000; Vanuatu; Kilbourne et al., 2004; Tahiti; Cahyarini et al., 2008; Fiji; Linsley et al., 2006; Wu et al., 2013; Amédée; Delong et al., 2012; Ha'afera, Tonga; Wu et al., 2013), two in the western equatorial Pacific Ocean (Rabaul; Quinn et al., 2006; Kavieng; Alibert et al., 2008), one in the Indonesian Throughflow region (Timor; Cahyarini et al., 2008), two in the western tropical South Indian Ocean (Madagascar and Mayotte; Zinke et al., 2004, 2008), one in the South China Sea (Xisha; Sun et al., 2005), one in the western subtropical North Pacific Ocean (Ogasawara; Felis et al., 2009) and one in the northern Red Sea (Aqaba; Felis et al., 2004) (Fig. 1 and Table 1).

Most of those records are monthly resolved except three at a 2-month resolution: the one from the western subtropical North Pacific Ocean (Ogasawara), the one from the Red Sea (Aqaba) and the one from Indian Ocean (Madagascar and Mayotte). One record from the western tropical South Pacific Ocean (Ha'afera, Tonga) is annually resolved and the one from the central Pacific Ocean (Rarotonga) is composed of eight points per year.

One of the most studied climatic mode of variability is the El Niño–Southern Oscillation (ENSO) that operates in the interannual band (typically 2 to 7 years) in the Pacific Ocean and has global impacts (Philander, 1990). Instrumental SST records being relatively short in the Pacific Ocean, corals have been used to extend them over the past several centuries and beyond to study the time evolution of ENSO (Cobb et al., 2003; Nurhati et al., 2010; DeLong et al., 2012; Gorman et al., 2012; Hereid et al., 2012; 2013). To highlight this interannual variability in our compiled coral records, we used two different methods on each time series: (1) a Hanning filter (Blackman and Tukey, 1958; Delcroix, 1998) was applied to filter out the seasonal variability (we used a 25-, 17- or 13-point Hanning filter depending on the record time resolution, i.e. 12, 8 or 6 months, respectively) and (2) annual averages where calculated. We did not apply a Hanning filter (which truncates records on both ends) to the Red Sea record due to its shortness (i.e. 5 years).

Table 1. List of the different coral sites location with corresponding references and periods of coral record used in this study.

Site number	Location	References	Period
1	Espiritu Santo, Vanuatu (15°7′ S–167°2′ E)	Kilbourne et al. (2004)	1981–1992
2	Kavieng, Papua New Guinea (2°5′ S–150°5′ E)	Alibert et al. (2008)	1981–1997
3	Rabaul, Papua New Guinea (4°S–152°E)	Quinn et al. (2006)	1981–1997
4	Amédée, New Caledonia (22°28′ S–166°28′ E)	DeLong et al. (2012)	1981–1999
5	Ha'afera, Tonga (19°9′ S–174°71′ W)	Wu et al. (2013)	1982–2003
6	Fiji (17°S–179°E)	Linsley et al. (2006)	1982–1997
7	Tahiti (17°S–149°W)	Cahyarini et al. (2008)	1982–1995
8	Rarotonga (21°14′ S–159°49′ W)	Linsley et al. (2000)	1981–1996
9	Christmas Island, Kiribati (1°52′ N–157°24′ W)	Nurhati et al. (2010)	1981–1998
10	Fanning, Kiribati (3°51′ N–159°21′ W)	Nurhati et al. (2010)	1981–2005
11	Palmyra, Central Pacific (5°53′ N–162°5′ W)	Nurhati et al. (2010)	1981–1998
12	Clipperton, East Pacific (10°18′ N–109°13′ W)	this paper	1982–2005
13	Xisha, China Sea (16°51′ N–112°20′ E)	Sun et al. (2004)	1981–1994
14	Ogasawara, Japan (27°6′ N–142°11′ E)	Felis et al. (2009)	1982–1994
15	Madagascar, Indian Ocean (23°8′ S–43°34′ E)	Zinke et al. (2004)	1981–1994
16	Mayotte, Indian Ocean (12°39′ S–45°06′ E)	Zinke et al. (2008)	1981–1994
17	Aqaba, Red Sea (29°27′ N–34°58′ E)	Felis et al. (2004)	1991–1996
18	Timor (10°S–123°E)	Cahyarini et al. (2008)	1985–2001

2.3 Data processing

To compare Sr / Ca to SST, a site-specific calibration is usually necessary to obtain the best-possible fit between the two variables (see Corrège 2006 for a compilation of published calibrations). This approach yields variable calibration slopes, indicating that the effect of other factors (vital effects, environmental influences, analytical bias (Hathorne et al., 2013), instrumental SST data set and statistical methods used for the calibration (Kawakubo et al., 2014); see Corrège, 2006, for a review) might be locally incorporated in the process. To free the records from the influence of these other factors on the Sr / Ca in corals, we used a single Sr / Ca–SST calibration equation that we applied to each coral record. The calibration equation corresponds to the average of the 38 linear regressions compiled by Corrège, 2006 ($\mathrm{Sr/Ca} = -0.0607 \times \mathrm{SST} + 10.553$; hereafter C06). However, the intercept of the C06 equation is representative of a mean SST of 25 °C, which is not the mean SST at all coral sites of our database. In order to minimize the site-specific mean SST effect, we elected to work with SST anomalies rather than absolute SST, using only the slope of C06

Table 2. Seasonally resolved coefficient of correlation (r) between residual temperature and salinity (SODA SSS and IRD SSS) and between instrumental SST and SSS (SODA and IRD) at the different locations used in this study. "ns" means not significant ($p > 0.01$). The significant correlations are significant at the 99 % confidence level. n is the number of values for each data set.

Location	r (ΔSST; SODA)	r (ΔSST; IRD)	r (SST; SODA)	r (SST; IRD)	n
1 – Espiritu Santo Vanuatu	ns	ns	−0.47	ns	128
2 – Kavieng, Papua New Guinea	ns	ns	ns	0.46	186
3 – Rabaul, Papua New Guinea	ns	ns	ns	ns	189
4 – Amédée, New Caledonia	ns	ns	ns	0.36	216
5 – Ha'afera, Tonga	ns	ns	ns	ns	22
6 – Fiji	ns	ns	−0.39	ns	186
7 – Tahiti	ns	ns	ns	−0.45	165
8 – Rarotonga	ns	ns	ns	ns	121
9 – Christmas Island, Kiribati	ns	ns	ns	ns	199
10 – Fanning, Kiribati	ns	ns	ns	−0.53	285
11 – Palmyra, Central Pacific	ns	ns	−0.49	−0.38	198
12 – Clipperton, Eastern Pacific	ns	ns	0.40	ns	275
13 – Xisha, China Sea	ns	–	ns	–	151
14 – Ogasawara, Japan	0.42	–	−0.66	–	79
15 – Madagascar, Indian Ocean	ns	–	ns	–	79
16 – Mayotte, Indian Ocean	ns	–	ns	–	75
17 – Aqaba, Red Sea	ns	–	ns	–	32
18 – Timor	ns	–	ns	–	204

Table 3. Interannually resolved (Hanning filter method, first line and annually averaged time series method, second line of each location) coefficients of correlation (r) between residual temperature and salinity (SODA SSS and IRD SSS) and between instrumental SST and SSS (SODA and IRD) at the different locations used in this study. "ns" means not significant ($p > 0.01$). The significant correlations are significant at the 99 % confidence level. n is the number of values for each record at both resolutions.

Location	r (ΔSST; SODA)	r (ΔSST; IRD)	r (SST; SODA)	r (SST; IRD)	n
1 – Espiritu Santo Vanuatu	ns	ns	−0.81	0.67	104
	ns	ns	ns	ns	11
2 – Kavieng, Papua New Guinea	0.53	ns	ns	0.86	162
	ns	ns	ns	0.80	15
3 – Rabaul, Papua New Guinea	ns	ns	ns	ns	164
	ns	ns	ns	ns	16
4 – Amédée, New Caledonia	ns	ns	−0.70	ns	192
	ns	ns	ns	ns	18
5 – Ha'afera, Tonga	ns	ns	ns	ns	22
6 – Fiji	ns	ns	−0.51	ns	162
	ns	ns	ns	ns	16
7 – Tahiti	0.48	−0.52	ns	ns	141
	ns	ns	ns	ns	14
8 – Rarotonga	ns	ns	ns	−0.76	78
	ns	ns	ns	ns	15
9 – Christmas Island, Kiribati	0.66	ns	ns	ns	176
	ns	ns	ns	ns	17
10 – Fanning, Kiribati	ns	0.61	ns	−0.61	261
	ns	ns	ns	−0.58	27
11 – Palmyra, central Pacific	ns	ns	−0.51	−0.49	175
	ns	ns	ns	−0.63	17
12 – Clipperton, eastern Pacific	ns	ns	ns	ns	251
	ns	ns	ns	ns	23
13 – Xisha, China Sea	ns	–	ns	–	127
	ns		ns		13
14 – Ogasawara, Japan	ns	–	ns	–	13
15 – Madagascar, Indian Ocean	–	–	–	–	43
	ns		ns		13
16 – Mayotte, Indian Ocean	ns	–	0.52	–	63
	ns		ns		12
17 – Aqaba, Red Sea	ns	–	ns	–	5
18 – Timor	ns	–	ns	–	180
	ns	–	ns	–	17

(SST = Sr / $\mathrm{Ca_{anom}}$ / −0.0607). We also use the rescaled bio-smoothing Sr / Ca–SST slope of Gagan et al. (2012) ($-0.084\,\mathrm{mmol\,mol^{-1}\,°C^{-1}}$) for a comparison. Moreover, in order to have a consistent instrumental reference, we chose to perform the Sr / Ca–SST calibrations using the OISST monthly product (version 2, Reynolds et al., 2002) for all Sr / Ca records. The OISST product blends instrumental data from different sources and is regularly updated. Additionally, this product is spatially complete due to the use of satellite-derived SST estimates (Deser et al., 2010). The use of other SST products (World Ocean Atlas SST, Levitus et al., 1994; and HadISST, Rayner et al., 2003) does not change our main conclusions. We selected for each site the closest SST grid point in the OISST product (Table S1 in the Supplement).

For each site we determined the instrumental SST anomaly ($\mathrm{SST_I}$) by removing the mean for each considered time interval; we thus calculated the residual temperatures ($\Delta\mathrm{SST} = \mathrm{SST_{Sr/Ca}}$–$\mathrm{SST_I}$). The monthly SST and SSS time series corresponding to the corals resolved at a 2-month resolution (Madagascar, Mayotte, Ogasawara, Ha'afera, Aqaba) and eight times per year (Rarotonga) have been resampled at the same resolution by calculating corresponding monthly average.

The relationships between ΔSST and the Simple Ocean Data Assimilation (SODA) SSS product (version 2.2.4, Carton and Giese, 2008; Fig. 1a and b) are characterized by the coefficient of correlation (r) and the corresponding p

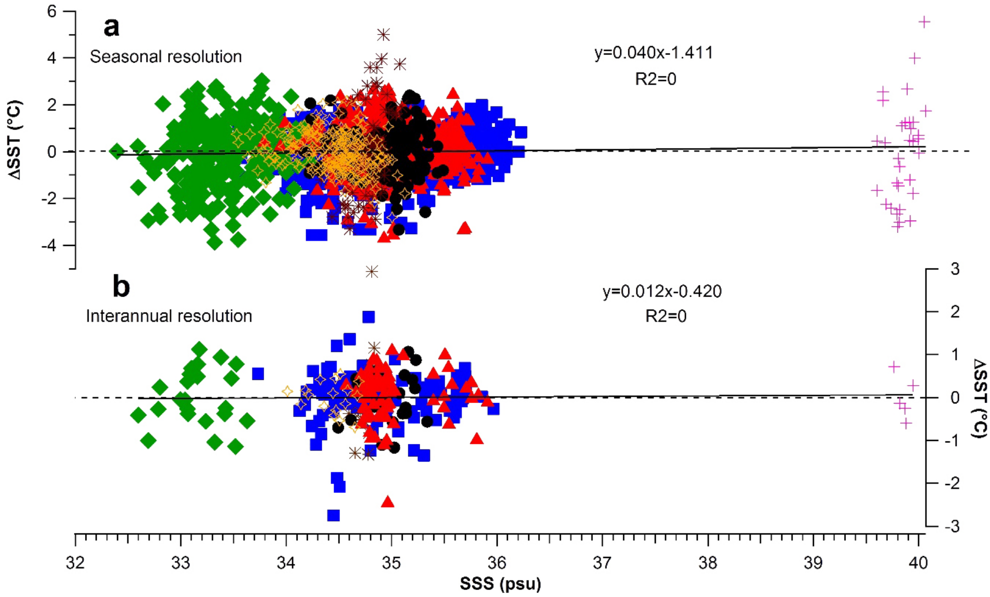

Figure 2. ΔSST ($= SST_{Sr\,/\,Ca}–SST_I$) plotted against salinity (SODA SSS product v2.2.4, Carton and Giese 2008) at seasonal **(a)** and interannual (annually averaged time series) **(b)** resolution for all coral data. Green diamonds: eastern tropical Pacific; blue squares: western tropical and subtropical Pacific; brown stars: western subtropical North Pacific Ocean; red triangles: central tropical Pacific; black circles: Indian Ocean; pink crosses: Red Sea; yellow diamonds: Indonesian region.

value at seasonal and interannual resolution (Fig. 2a and Table 2; Fig. 2b and Table 3, respectively). As with SST, we used the closest SSS grid point for each location (Table S1). The SODA SSS is a reanalysis product involving modelling and data assimilation, but unfortunately, it lacks salinity data in several oceanic regions. However, the SODA SSS product is the only global ocean gridded SSS database currently available, making it the only possible choice for this study. To test the potential limitation of the seasonal and interannual SSS variability in the SODA SSS product at our sites, we investigated the correlation between ΔT and SSS using the $1° \times 1°$ gridded instrumental IRD SSS product (covering 120°E–70°W, 30°N–30°S; Delcroix et al., 2011) at 12 tropical Pacific sites of our database (Fig. 1c and Table S2 and 3). The IRD SSS product data set is made freely available by the French Sea Surface Salinity Observation Service (http://www.legos.obs-mip.fr/observations/sss/). As for SODA SSS, we resampled the corresponding IRD SSS monthly average for the five at a 2-month resolution and the eight-times-per-year coral records.

3 Results and discussion

We first look at each individual records at seasonal resolution. We observe no relationship between ΔSST and SODA SSS/IRD SSS at seasonal resolution except for the Ogasawara location ($r = 0.42$ (SODA); $p < 0.01$; Table 2). There are no rivers surrounding this core location ruling out any freshwater input that could have modified the Sr / Ca seawater concentration (Felis et al., 2009). One possible explanation for this correlation could be that the use of the averaged calibration slope C06 does not allow one to fully reconstruct the seasonal SST cycle at some locations. The ΔSST could then still contain part of the seasonal SST variation. In addition, the Ogasawara instrumental SSS and SST also present a significant correlation ($r = -0.66$; $p < 0.01$; Table 2); therefore, the relationship between ΔSST and SSS products could be a consequence of this seasonal coupling between salinity and temperature variations.

In order to test the potential influence of salinity variation on the SST reconstruction, we have to consider our compilation from a global point of view. We plot all the individual records together and no significant relationship ($r = 0$; $p > 0.01$; $n = 2799$; Fig. 2a) appears between ΔSST and SSS over the investigated salinity range (~ 7 psu, SODA SSS, Fig. 2a; ~ 3 psu, IRD SSS, not shown). The ΔSST values present a dispersion between $+4$ and -4 °C (Fig. 2a); the reasons for this dispersion could be threefold: (1) the use of the mean slope C06, which is not the best fit between Sr / Ca and SST_I for each site, (2) the fact that the gridded OISST data product could not truly represent the SST seasonal range at some of our coral sites and (3) potential interlaboratory biases, as recently highlighted by Hathorne et al. (2013), even though working with Sr / Ca anomalies minimizes these offsets. Thus, we strongly support the conclusion drawn by Hathorne et al. (2013) stating that future Sr / Ca coral data should always be corrected using an international standard.

We then look at each individual records at interannual resolution using both a Hanning filter and an annual average method. No significant relationship between ΔSST and SODA SSS is found when using the annually averaged time series. However, when using the Hanning filter, the Kavieng, Tahiti, Christmas Island and Fanning locations present significant relationships between ΔSST and SODA SSS/IRD SSS ($r = 0.53$ (SODA), $r = 0.48$ (SODA), $r = 0.52$ (IRD), $r = 0.66$ (SODA) and $r = 0.61$ (IRD), respectively; $p < 0.01$; Table 3). Significant correlations can also be noted between instrumental SST and SSS at several locations, mostly with Hanning filtered data. This probably highlights the fact that the Hanning filter does not completely filter out the seasonal variability, and that the correlation between SST and SSS documented at monthly resolution is still present in some records.

We then plotted all the individual interannual records together and it shows that even at this timescale (no matter the method), salinity has no significant influence on the Sr / Ca-based palaeothermometer in corals ($r = 0$; $p > 0.01$; $n = 2279$ (Hanning filter) and $n = 297$ (annual average)) over the investigated salinity range (∼ 7 psu, SODA SSS, Fig. 2b shows the annually averaged time series method; ∼ 3 psu, IRD SSS, figure not shown). This result is robust and is not affected by the use of the rescaled slope of Gagan et al. (2012).

As previously mentioned, the SODA SSS is a reanalysis product and as such, it can have serious biases in regions where the data coverage is poor (Carton and Giese, 2008). In order to test whether the significant correlation found between ΔSST and SODA SSS at some location is robust, we calculated the correlation between ΔSST and SSS at seasonal and interannual resolution using both SODA SSS and IRD SSS products (Delcroix et al., 2011) at 12 tropical Pacific sites. First, it should be mentioned that the agreement between both SSS products is variable and usually poor ($r = 0$ to 0.55 at seasonal resolution ($p < 0.01$) and $r = 0$ to 0.67 at an interannual timescale ($p < 0.01$)). However, at both timescales, no systematic difference between correlations is observed when using the IRD SSS product in comparison to the SODA SSS product (Tables 2 and 3).

Results presented in this study are in agreement with previous laboratory investigations from Zhong and Mucci (1989) which concluded that for synthetic aragonite precipitated in seawater solutions of various salinities (from 5 to 44 psu), the incorporation of Sr^{2+} is unaffected by salinity variations. Our results are also in agreement with the recently published work of Pretet et al. (2013), who investigated the effect of salinity on the skeletal chemistry of cultured corals *Acropora* sp., *Montipora verrucosa* and *Stylophora pistillata*. The three coral genera were bred in three different aquaria with artificial seawater and at a salinity of 36, 38 and 40 psu, respectively. Although Pretet et al. (2013) did not work with *Porites* spp. and had a smaller salinity range, they reached similar conclusion; Sr / Ca and other elemental ratios (Mg / Ca; Li / Ca; U / Ca) measured in the coral skeleton do not vary with salinity changes.

4 Conclusions

To strengthen our confidence in the *Porites* Sr / Ca palaeothermometer, we have to test for potential biases. In the present study, we investigate a possible salinity effect on coral Sr / Ca-based SST reconstructions at monthly and interannual timescales, in open-ocean environmental conditions, using a large spatial compilation of published and new *Porites* data. We find no evidence for a salinity perturbation of the Sr / Ca thermometer in *Porites* in open-ocean conditions, in agreement with the coastal studies of Alibert et al. (2003) and Fallon et al. (2003), and the laboratory study of Pretet et al. (2013). This result reinforces our confidence in this tracer and makes it suitable for palaeo-SST reconstructions. Further work should include laboratory experiments with the *Porites* genus, although its slow growth rate has so far been an obstacle.

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